
Space Weather Technical Forecast

Issued on Tuesday, 14 March 2023 at 01:26 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Chance of Minor Geomagnetic storms due to possible glancing CMEs and CH84 enhancement on day 2 (15th). S1/Minor Radiation storm from far-sided eruption now eased.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with only isolated C-flares observed, peaking C3.1 at 13/1105 UTC from a filament eruption near centre disc in the northern hemisphere. There are six numbered sunspot regions on the visible disc however these are all generally small, simple and mature regions that are either stable or showing signs of decay. The only exception is a seventh newly developing region in the southern centre disc. This is currently a small bipolar region, but has the potential for further development with ongoing flux emergence.

A moderately fast CME was associated with the filament eruption mentioned above at 13/1105 UTC. This has been analysed as largely passing to the north and ahead of Earth, however glancing influences are possible on day 2 (15th). A further full very fast full halo CME was observed at 13/0336 UTC on coronagraph imagery. This was from a significant far-sided eruption, moving away from Earth.

Solar Wind / Geomagnetic Activity: The solar wind observed at L1, has been indicative of a slow wind environment, with its speed easing from 380km/s to 310 km/s. The density has been average or just above average. The total IMF strength was initially weak, but rose to be moderate by 13/1500 UTC, peaking at 10nT. The north-south component was mainly positive, ranging between -1 and + 9nT. The Phi angle was initially negative (towards the Sun), but rotated to be positive (away from the Sun) from 13/1600 UTC. Geomagnetic activity was Quiet (Kp 0-1).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 increased from 13/0500 UTC in response to the large far sided CME, rising to around the S1 minor storm level. This peaked at 13 pfu at 13/1435 UTC. The greater than 100 MeV energy channel also increased to slightly elevated levels, but remained below the 1 pfu threshold. The proton flux remains elevated, but below the S1 level since 13/1655 UTC. The high energy electron flux (greater than 2MeV) has been at moderate to background levels. The associated 24 hour Electron fluence has remained below Active. At 14/0000UTC the observed fluence was 1.07e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is generally expected to be Low or Very Low, with isolated C-class flares.

Solar Wind / Geomagnetic Activity: Glancing CME impacts are possible late day 1 (14th) and through day 2 (15th) due to three filament eruptions that occurred on the 10th, 12th and 13th. These are all low confidence, however any combined effect could give a larger geomagnetic response than normally expected from such glancing impacts. Otherwise, slow solar winds are likely to become slightly elevated later day 1 (14th) and through day 2 (15th) due to the arrival of fast winds from CH84/+. Quiet geomagnetic activity at first day 1 (14th) is expected to become

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Quiet to Unsettled with a chance of Active intervals day 2 (15th) (Kp 0-4). The arrival of any CMEs will likely bring Active intervals with a chance of G1 Minor Storm intervals (Kp 4-5) with this risk continuing into day 3 (16th) before easing later with mainly Quiet (Kp 0-2) conditions returning by day 4 (17th).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux, as observed by GOES16, is currently slightly elevated, but expected to gradually decline to background levels. High energy electron flux levels (greater than 2MeV) are expected to be at Background to Moderate, with the associated 24 hour fluence expected to remain below the Active ($1e8$ integrated pfu) threshold.

Figure 1a. SOHO Coronagraph imagery of fast far-sided CME

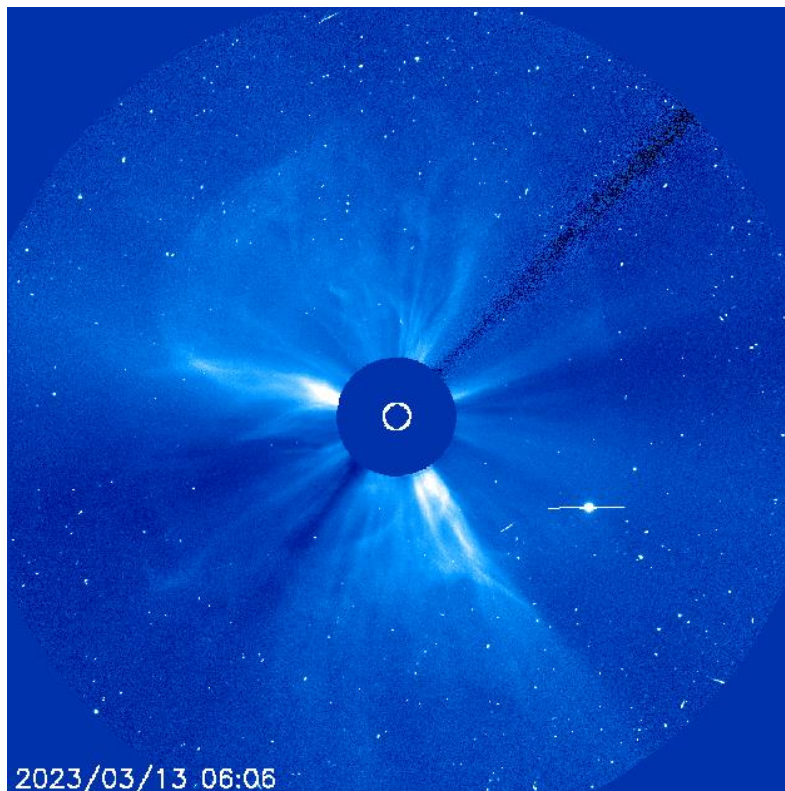
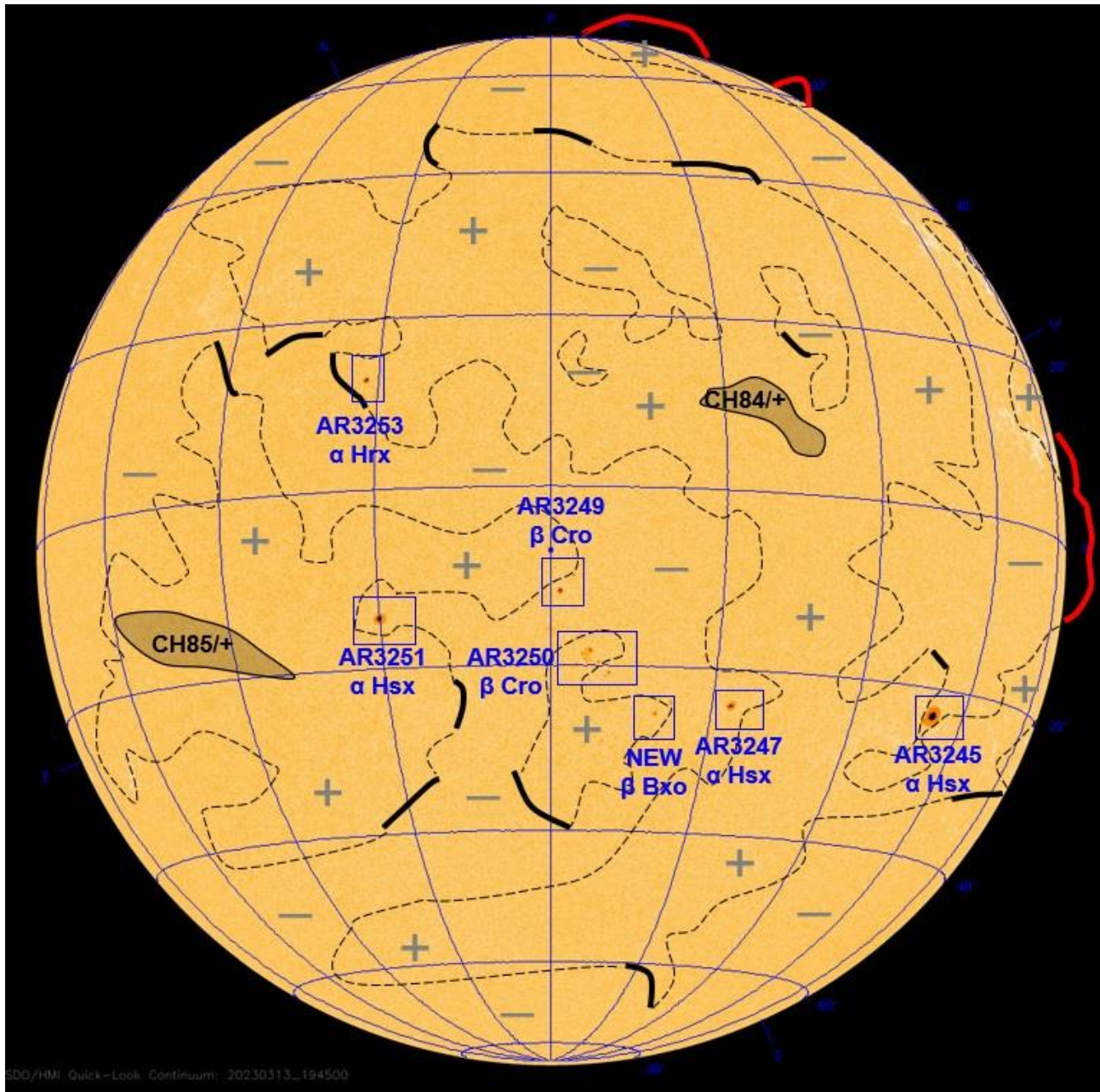


Figure 1b. Solar Analysis Valid 13/2000 UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

There are a number of CME arrivals, however all are low confidence. The first, from a filament eruption off the southwest quadrant on 10 March may pass close enough to Earth to give some glancing influence late on day 1 (14th) into day 2 (15th). A further filament eruption from the southeast disc on 12 March may then glance Earth late on day 2. A faster filament eruption off the northwest disc later on the 12 March is also expected to pass largely north and ahead of Earth, however this too may give a glancing impact during the 15th, perhaps arriving earlier in the day.

Confidence in the impacts from these events is low, however given the number of CMEs potentially arriving in a period of 24-36 hours cumulative impacts may result in a stronger geomagnetic response than would normally be expected for such events.

Furthermore, the current background slow wind conditions are expected to become enhanced later on the 14th and during the 15th as Earth moves into the fast wind from CH84/+. This is disfavoured for a strong connection around the March equinox due to the Russell Mcpherron effect, however will likely aid to increase activity levels given any CME arrival. Any fast wind and CME influence is expected to gradually recede later day 3 and 4 (16th and 17th).

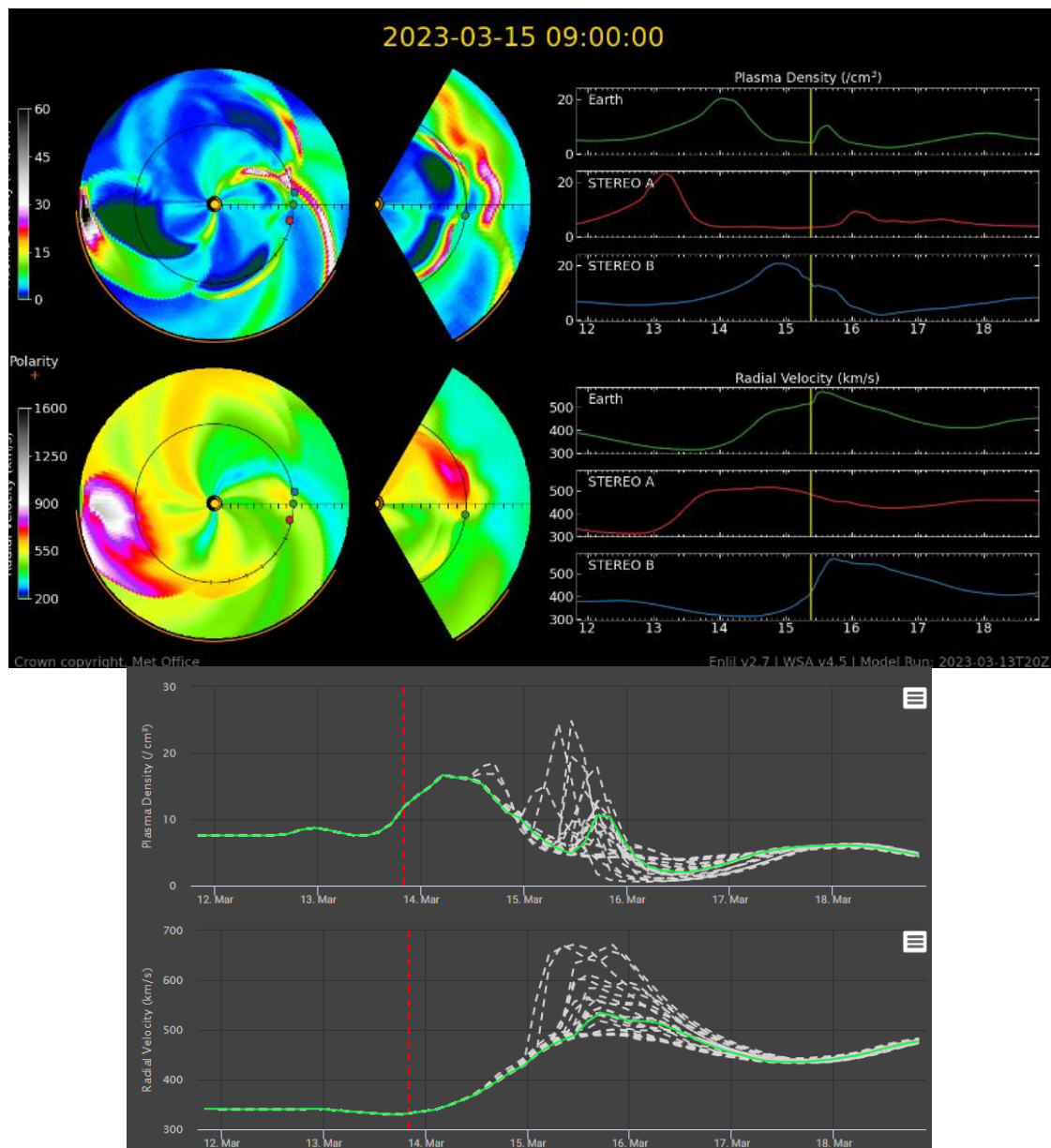
Quiet geomagnetic activity at first day 1 (14th) is expected to become Quiet to Unsettled with a chance of Active intervals day 2 (15th) due to the arrival of any fast winds from CH84/+. However, the arrival of any of the three CMEs will likely bring Active intervals with a chance of G1 Minor Storm intervals, and with this risk continuing into day 3 (16th). With the low chance of the combined effect of a series of arrivals a very isolated G2 Moderate storm cannot be completely ruled out. This is very low confidence however. Any enhancement is likely to ease through day 3 (16th), with mainly Quiet conditions returning by day 4 (17th).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	20	40	30	1
Strong	G3	No	1	2	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/0102	Partial	Filament	SW	495 km/s	Missing	Glance possible late 14 th /early 15 th
12/2340	Partial	Filament	SE	760 km/s	15/1800 +/- 6 hrs	Glancing impact
13/1319	Partial	Filament	N	1334 km/s	15/1200 +/- 9hrs	Likely passing over Earth, but chance of glance.

Figure 2: Enlil and ensemble showing potential CME glancing impacts. Far-side CME also visible.

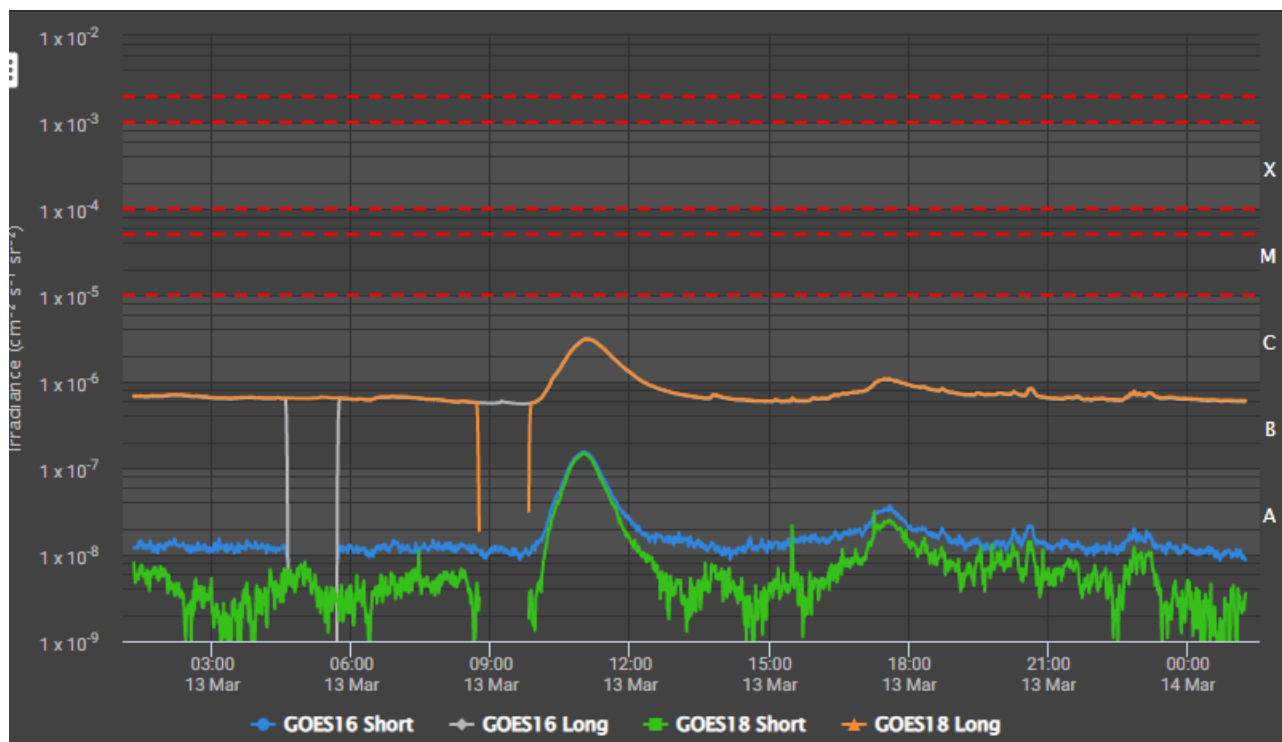


Radio Blackouts - X-Ray Flares:

Low to Very low Activity is expected to continue through the period with only isolated C-class flares. There are six numbered and one unnumbered sunspot regions on the disc. These are generally small and mature regions, that are either stable or declining with the only notable growth across in the new region in the south-centre disc, although this currently remains a small and simple region. There are also a number of filaments on the Earth-facing disc, however, and these could also be a source of further low level flare activity.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	5	5	5	5
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: GOES-16/18 X-ray Flux



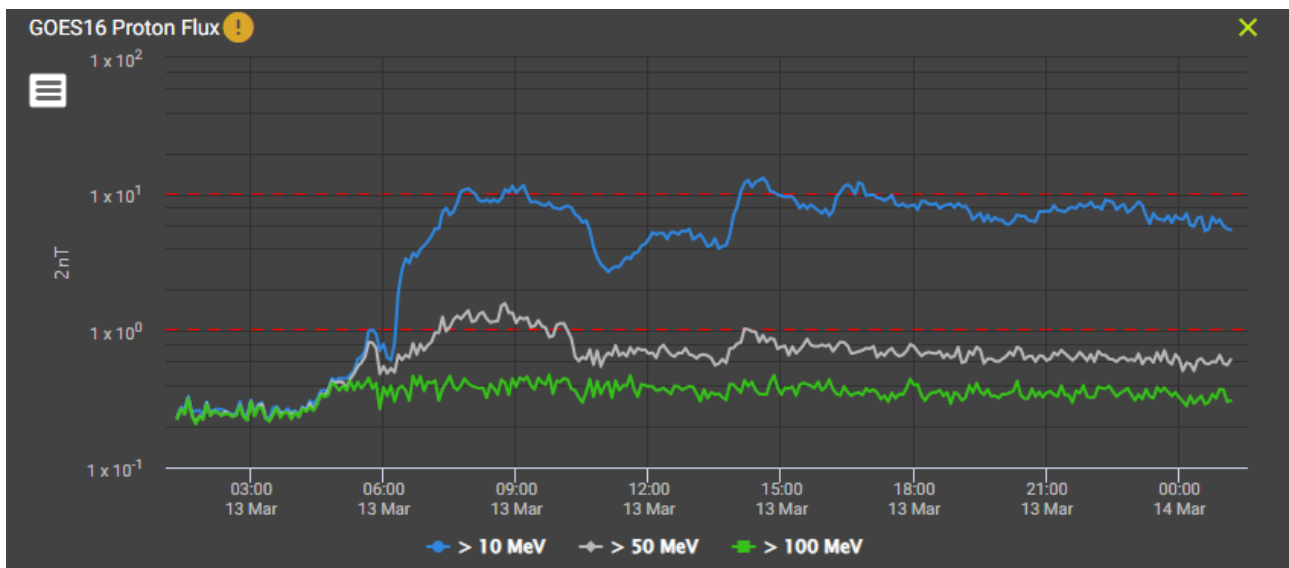
Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux has been enhanced through the 13th, due to the significant far-sided event which produced a very fast far-sided CME. Despite its location almost directly opposite Earth, proton flux responded and reached the S1/Minor Radiation Storm threshold at times. Further brief spells at this level remain possible early on day 1 (14th), before a gradual decline in values back towards background is expected through the period. Given the simplicity of the sunspots currently on the disc, no further enhancements are expected, unless similar far-sided eruptions occur.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	Yes	10	1	1	1
Very Active	$\geq \text{S3}$ *	No	1	1	1	1

* S3 $\geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)

Figure 4: GOES 16 >10MeV, >50MeV and >100 MeV Proton flux



High Energy Electrons Event ($\geq 2\text{MeV}$):

The high energy (greater than 2 MeV) electron flux at GEO, as observed by GOES-16, is expected to persist at Background to Moderate levels. The arrival of fast winds from CH84/+ or any CME is likely to drop electron fluxed further, to mainly background. With only a weak connection to these features anticipated, flux levels are likely to then persist at mainly background, perhaps rising to Moderate by the end of the period.

The associated 24 hour electron fluence is expected to persist at below the Active level and likely declining. REFM is currently giving a good guide to expected conditions before any enhanced wind environment occurs from the fast wind of CH84/+ or any potential CME arrival.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	5	10
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 5: GOES 16 $>2\text{MeV}$ Electron Flux and associated fluence with REFM

